Evaluations of bronchoplasty and pulmonary artery reconstruction for bronchogenic carcinoma

Feng Chunwei*, Wu Weiji, Zhou Xinguan, Ni Qingzen, Jiang Xiangmin, Zhang Qingzhen

Department of Thoracic Surgery, Jiangsu Institute of Cancer Research, Baziting 42#, Nanjing 210009, People’s Republic of China

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Abstract

Objective: To evaluate the surgical results of bronchovascular reconstruction and the prognostic factors for lung cancer. Methods: From 1976 to 1995, 78 patients with a mean age of 55.1 years (range 26–69 years) underwent bronchoplasty for non-small-cell lung cancer (NSCLC) including pulmonary artery (PA) reconstruction in 21 patients. There were 47 right upper lobectomies (60.3%), 24 left upper lobectomies (30.8%), and seven other atypical types of operations (8.9%). The bronchoplasty was a full sleeve in 71 patients, and a bronchial wedge resection in seven. Thirteen PA tangential resections and eight PA sleeve resections were performed. Tissue diagnosis was squamous cell carcinoma in 56 patients, adenocarcinoma in six, adenosquamous carcinoma in ten, neuroendocrine carcinoma in two and others in four. No patient had a microscopically positive bronchial resection margin. The follow up is complete for all patients. Seventy-five patients were statistically analyzed using STATA software. The survival rate was calculated with life table method. Comparisons of the difference of survival rates between groups were made according to the log–rank test. Results: The operative mortality rate (30 days) was 3.8% (3/78). The prolonged atelectasis necessitating repeated bronchoscopy was the most common major complication which occurred in 12 patients (16%). Tumor recurrence around the anastomotic site confirmed by bronchoscopic biopsy was observed in four patients. The overall survival at 5 and 10 years was 48.9 and 38.8%, respectively. The 5- and 10-year survival for patients with stage I disease were 66.1 and 57.5%, and for patients with stage II were 62.8 and 44.2%, respectively. The 3- and 5-year survivals for patients with stage III were 11.1 and 0%, respectively (P = 0.0000). The 5-year survival rates for those with N0 tumor (n = 36) were 63.3%, 53.6% for those with N1 (n = 26), and with no survivors for N2 (n = 13), respectively (P = 0.0000). The 5- and 10-year survival rates with bronchoplasty (n = 54) were 55.0 and 47.8%, and 33.3 and 16.7% with bronchovascular reconstruction (n = 21), respectively (P = 0.0033). Multivariate analysis showed that long-term results were influenced chiefly by nodal stage among five factors of pT, pN, bronchoplasty with or without PA reconstruction, cell types, and postoperative adjuvants (P = 0.004). Conclusions: Any type of lobectomy with bronchial reconstruction is an adequate cancer operation for both compromised and uncompromised patients especially in patients with stages I and II lung cancer with reasonably good results. Sleeve lobectomy with PA reconstruction may finally be indicated in patients considered compromised because of cardiac or respiratory impairment contraindicating pneumonectomy.

Keywords: Lung neoplasms; Surgery; Prognosis; Bronchoplasty; Pulmonary artery reconstruction

1. Introduction

The preservation of pulmonary tissue is widely accepted in surgery of the lung. One common method of this technique is the lobectomy with bronchial reconstruction, which has been used more frequently in the treatment of lung cancer. Since the sleeve lobectomy yielded survival results which were at least equal to those of the pneumonectomy but provided better functional results, it has become an accepted procedure for the patients who have lung cancer and anatomically suitable tumors, regardless of the pulmonary function [1,2]. As the techniques for angioplasty have been introduced into the field of pulmonary surgery, sleeve lobectomy with pulmonary artery (PA) reconstruction has become feasible. In this paper, results of the bronchoplasty and PA reconstruction for patients with lung cancer will be presented and evaluated.

2. Materials and methods

From 1976 to 1995, 78 patients with lung cancer were surgically treated with the bronchial reconstruction, of which 21 patients were treated with PA reconstruction. There were 59 men and 19 women whose age distribution
ranged from 26 to 69 with a mean age of 55.1. Information was gathered from office records and personal contact with patients and their families.

2.1. Surgical indications

Bronchoplasty is the procedure of choice for anatomically suitable central lung cancer or when reduced pulmonary reserve precludes extensive resection, for which the alternative is a pneumonectomy. When tumor surrounding the upper lobe or main bronchus and involving PA to a variable extent or full circumference, bronchovascular reconstruction is indicated. If the radical resection cannot be performed or the two ends of PA cannot be brought together, pneumonectomy is performed. If the patients with inadequate pulmonary or/and cardiac function cannot tolerate a pneumonectomy, palliative bronchoplasty is done.

Chest films and computerised tomographic (CT) examination combined with precise bronchoscopic assessment define the need and probability for bronchoplasty and PA reconstruction. Bronchoscopy is done by thoracic surgeons. When tumor from a lobe orifice is found, cartilage rings of main-stem bronchus are counted to delineate the extent of tumor and plan the resection lines. In this series, 61 patients (78.2%) had an obvious tumor bulge from a lobe orifice, 11 patients (14.1%) had narrow change in bronchial lumen, and six patients (7.7%) were normal under bronchoscopy. Twenty-six patients (34.7%) had inadequate pulmonary and cardiac function to tolerate pneumonectomy.

2.2. Operative technique

The procedure for bronchoplasty was identical to that for standard lobectomy until the bronchus was isolated. Care was taken not to devascularize the bronchus beyond the proposed line. Frozen section examinations were routinely done by sending a thin ring of tissue from the margins to be anastomosed. The bronchial anastomoses were performed with interrupted absorbable 3-0 sutures applied transmurally, knots being tied outside the bronchial lumen. Any luminal disparity was equalized by stretching the smaller lumen to the size of the larger one. When the operation associated with a double reconstruction of the bronchus and PA, PA was performed with clamping proximal and distal stumps, and running 4-0 or 5-0 absorbable sutures after completion of the bronchial anastomosis. Some measures such as systemic or local anticoagulation and a viable tissue flap to reinforce the suture line were not used in all patients.

The reconstruction mode of the bronchus is shown in Table 1. Among the types of the reconstructed bronchial tree for carcinoma, the most common one was the right upper lobectomy, which was performed on 47 patients (60.3%). Twenty-four patients (30.8%) underwent a left upper lobectomy. Other atypical types of operations were right upper and middle lobectomy, right middle lobectomy, right middle and lower lobectomy, right lower lobectomy, and left lower lobectomy. Two patients underwent a right upper sleeve lobectomy simultaneously with a resection of partial superior vena cava. Bronchoplasty was done to use sleeve lobectomy in 71 patients (91%), and a wedge resection in seven (9%). Among those cases, bronchoplasty with PA reconstruction was performed on 21 patients (26.9%) (13 PA tangential resections and eight PA sleeve resection).

2.3. Histopathology and stage of disease

As details of the histologic types and the surgicopathological stages given in Table 2, 56 patients had squamous cell carcinoma, six had adenocarcinoma, ten had adenosquamous cell carcinoma, two had adenoid cystic carcinoma, and four were other types. As per the tumor stage scale associated with a double reconstruction of the bronchus and PA, PA was performed with clamping proximal and distal stumps, and running 4-0 or 5-0 absorbable sutures after completion of the bronchial anastomosis. Some measures such as systemic or local anticoagulation and a viable tissue flap to reinforce the suture line were not used in all patients.

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Table 1
Surgical procedures

<table>
<thead>
<tr>
<th>Site</th>
<th>Wedge</th>
<th>Sleeve</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right upper lobe</td>
<td>2</td>
<td>45 (4*) (3**)</td>
<td>47 (4*) (3**)</td>
</tr>
<tr>
<td>Right upper and middle lobes</td>
<td>1 (1*)</td>
<td>1 (1*)</td>
<td></td>
</tr>
<tr>
<td>Right middle lobes</td>
<td>1 (1**)</td>
<td>1 (1**)</td>
<td></td>
</tr>
<tr>
<td>Right middle and lower lobe</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Right lower lobe</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Left upper lobe</td>
<td>5 (1*) (1**)</td>
<td>19 (7*) (2**)</td>
<td>24 (8*) (3**)</td>
</tr>
<tr>
<td>Left lower lobe</td>
<td>2 (1**)</td>
<td>2 (1**)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7 (1*) (1**)</td>
<td>71 (12*) (7**)</td>
<td>78 (13*) (8**)</td>
</tr>
</tbody>
</table>

* *, Figures in parentheses indicate tangential resection of PA; **, figures in parentheses indicate sleeve resection of PA.

Table 2
Distribution of patients by histopathologic type and stage (n = 78)

<table>
<thead>
<tr>
<th>Cell type</th>
<th>Stage I</th>
<th>Stage II</th>
<th>Stage III</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a</td>
<td>b</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Squamous cell ca.</td>
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<td>22</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>Adenocarcinoma</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Adenosquamous</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Adenoid cystic ca.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>28</td>
<td>2</td>
<td>26</td>
</tr>
</tbody>
</table>
(modified in 1997), four patients were with stage Ia, 28 with stage Ib, two with stage IIa, 26 with stage IIb, eight with stage IIIa, and ten with stage IIIb. The postoperative TNM histopathological classification of the 78 patients is summarized in Table 3.

2.4. Statistical methods

Of the 78 patients, 75 patients who underwent resections were statistically analyzed by using the STATA software. The survival rate was calculated with the life table method. Comparisons between the groups with the different survival rates were made according to the log–rank test.

3. Results

For the 78 patients in this series, 73 of the operations were considered to be curative, and five non-curative because of pulmonary (n = 3) and cardiac (n = 2) impairment contra-indicating pneumonectomy. The operative mortality rate (30 days) was 3.8% (3/78). One of the three patients died from an acute upper digestive hemorrhage after 10 days of the operation, and two died from thoracic infections on the 15th and 27th day after the surgery, respectively. The three were excluded from the evaluation. No patient had a macroscopic positive bronchial resection margin. The prolonged atelectasis necessitating repeated bronchoscopy was the most common major complication, and it occurred in 12 patients (16%). There were no instances of anastomotic dehiscence, bronchovascular fistula, or late significant non-neoplastic bronchial strictures in this series. The overall survival rates at 1, 3, 5, and 10 years were 85.3, 55.8, 48.9, and 38.8%, respectively.

The majority of tumors observed in the discussed series were squamous carcinomas (56 out of 75, 74.7%). Survival rates for squamous cell carcinoma were 85.5, 50.5, 41, and 35.9% for 1, 3, 5, and 10 years, respectively. No patients with adenocarcinoma survived for more than 5 years post-operatively (P = 0.0875).

The 1-, 3-, 5- and 10-year survivals for patients with stage I disease were 96.7, 69.5, 66.1 and 57.5%, and for patients with stage II were 88.9, 70.4, 62.8, and 44.2%, respectively. The 1-, 3- and 5-year survivals for patients with stage III were 61.1, 11.1, and 0%, respectively. Differences observed in the survival rates were statistically significant between the patients with stages I, II and III diseases (Fig. 1) (P = 0.0000).

The survival rate of six patients with pT1 tumor was 50%
at 5 years. For the 54 patients with pT2 lesions, the survival rates were 88.9, 64.5, 56.9, and 44.8% for 1, 3, 5, and 10 years, respectively. In a group of five patients with pT3 disease, the survival rate was 36% at 5 years. In a group of ten patients with pT4, the survival rates were 60 and 10% at 1 and 3 years, respectively, and none survived for more than 5 years in this group. In conclusion, the survival rates at 1 and 3 years, respectively, and none survived for more than 5 years. For the 26 patients with N1 tumor, the values were 80.8, 61.5, 53.6, and 39.0% for 1, 3, 5, and 10 years, respectively. However, survival rates for the 13 patients with N2 tumor were 61.5 and 7.7% at 1 and 3 years, respectively, and no patients survived for more than 5 years. Based on the results, the survival rates with various pN also differed considerably ($P = 0.0007$).

In this series, survival rates of the 36 patients with N0 lung cancer were 87.2, 69.0, 63.3, and 52.7% at 1, 3, 5, and 10 years, respectively. For the 26 patients with N1 tumor, the values were 80.8, 61.5, 53.6, and 39.0% for 1, 3, 5, and 10 years, respectively. However, survival rates for the 13 patients with N2 tumor were 61.5 and 7.7% at 1 and 3 years, respectively, and no patients survived for more than 5 years. Based on the results, the survival rates with various pN also differed considerably ($P = 0.0000$).

For the 21 patients who underwent bronchoplasty with PA reconstruction, 12 had left PA and nine had right PA (Table 1), and the survival was 71.4, 38.1, 33.3, and 16.7% at 1, 3, 5, and 10 years, respectively. For the 54 patients who underwent bronchoplasty but without PA reconstruction, survival rates were 90.7, 62.7, 55.0, and 47.8% at 1, 3, 5, and 10 years, respectively. Considerable differences were observed between the two groups ($P = 0.0033$).

Of the 34 patients who did not undergo adjuvant therapy postoperatively, 25 patients were treated with chemotherapy, 14 received radiotherapy, and two had both chemotherapy and radiotherapy. No notable differences were observed in the survival rates for the three ($P = 0.9604$).

Multivariate analysis showed that long-term results were influenced mainly by nodal stage among the five factors: pT, pN, bronchoplasty with or without PA reconstruction, cell types, and postoperative adjuvants ($P = 0.004$).

Postoperatively, tumor recurrence around the anastomotic site confirmed by bronchoscopic biopsy was observed in four patients who underwent reconstruction of the bronchus in a period of 8–20 months. Of these patients, three had a wedge lobectomy and one received a sleeve lobectomy. Twelve patients were found to have local recurrence by chest CT scans. Thirty-two patients died of multiple distant metastases including eight patients with local recurrence. The data of 5-year survival rate showed that eight patients died of local recurrence (21.1%), and 27 patients died of multiple distant metastases (70.1%).

4. Discussion

The reported 5-year survival rate for sleeve lobectomy depended on the stage and the pulmonary functional reserve [3–5]. However, discussions are still focused on whether sleeve lobectomy for advanced bronchogenic carcinoma could be an alternative to the pneumonectomy. From recent reports, bronchoplastic resections achieve local control and long-term survival when compared to standard resections in patients with stage I or II disease, and may be considered as a valuable alternative to pneumonectomy [6,7]. In our data, except for those with stage III disease, the 5-year survival rates of stages I and II were better than the reported result of the surgical treatment for bronchogenic carcinoma [8]. We believe that the bronchial reconstruction can now be conducted on the patients with the stages I and II lung cancer.

Patients with squamous cell carcinoma seemed to benefit from sleeve lobectomy. However, a few number of patients with adenocarcinoma and others can be used for us to conclude how histologic type can affect the survival. Based on the reported data, it is still controversial that whether the patients with N1 and N2 diseases should undergo bronchoplasty. Some demonstrated that survival rate depends on the stage of the disease rather than the technique of the resection. Long-term survival is particularly influenced by the extent of metastasis to hilar (N1) and mediastinal nodes (N2), and most of these patients died from distant metastases [9,10]. Comparison in survival between sleeve lobectomy and pneumonectomy according to the nodal status and stage demonstrated little difference [1]. Our data showed that long-term results were influenced chiefly by the nodal stage, and the survival rates with various pN differed considerably. We found that eight of the patients with N2 diseases (8/13, 61.5%) had distant metastases, which confirmed the reported data. These data suggest that bronchoplastic procedures are also adequate for patients with N2 diseases in normal pulmonary functional reserve.

In our series, the prognosis for sleeve lobectomy with PA reconstruction (double-sleeve procedure) was not satisfactory. The result indicates that surgical reconstruction of the bronchus and PA can be an alternative to pneumonectomy when pneumonectomy is contraindicated due to low cardiopulmonary reserve.

Adjuvant therapies for non-small-cell lung cancer were found to have no significant effects on survival rates in surgical patients, and combined therapies were commonly exercised for non-surgical patients [11]. Surgery is the primary treatment for stages I and II, but the treatment for patients with stage III is somewhat in flux. The multimodal therapy including chemotherapy, radiation therapy, and surgical resection, however, is currently recommended [12]. Our data showed that there was no observed improvement in survival with the use of adjuvants, which might be influenced by the diversity in distribution of patients and therapeutic methods.

The therapeutic goal for extended operation is to do palliative resection so as to relieve symptoms and improve patients’ quality of life and survival, which is most appropriate to postoperative combined therapy. A few of 5-year survivors without any recurrence of lung cancer have been reported recently [13]. In our series, two patients survived for 8 and 21 months with postoperative multimodal therapy, and died of brain and vertebral body metastases, respec-
tively. Therefore, we believe that the indication may need to be discussed and further evaluated.

Postoperative cancer recurrence around the anastomotic site may appear, even though histologic evaluation of the resected bronchus showed no evidence of disease. In our series, we encountered four patients (5.3%) with postoperative anastomotic recurrence, which occurred in three patients by wedge lobectomy (42.9%), and was much higher than sleeve lobectomy (1.4%). To prevent postoperative local tumor recurrence around the anastomotic site, the excision of the bronchus should be wider than indicated by the histologic results of frozen sections of the bronchial stump during the operation. In addition to this procedure, it may be necessary to perform prophylactic postoperative irradiation to the anastomotic site for advanced diseases.

5. Conclusions

1. Any type of lobectomy with reconstruction of the bronchus can be performed, especially for patients with stages I and II lung cancer with reasonably good results.
2. Sleeve lobectomy with PA reconstruction may finally be applied to patients considered compromised due to severe cardiac or respiratory impairment contraindicating pneumonectomy.

References